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Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors

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ANSI/ANS 8.12, Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors

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INTRODUCTION

The ANSI/ANS 8.12 standard was first approved in July 1978. At that time, this edition was applicable to operations with plutonium-uranium oxide (MOX) fuel mixtures outside reactors and was limited to subcritical limits for homogeneous systems. The next major revision, ANSI/ANS-8.12-1987, included the addition of subcritical limits for heterogeneous systems. The standard was subsequently reaffirmed in February 1993.

During late 1990s, substantial work was done by the ANS 8.12 Standard Working Group to re-examine the technical data presented in the standard using the latest codes and cross section sets. Calculations performed showed good agreement with the values published in the standard. This effort resulted in the reaffirmation of the standard in March 2002.

The standard is currently in a maintenance mode. After 2002, activities included discussions to determine the future direction of the standard and to follow the MOX standard development by the International Standard Organization (ISO).[1] In 2007, the Working Group decided to revise the standard to extend the areas of applicability by providing a wider range of subcritical data. The intent is to cover a wider domain of MOX fuel fabrication and operations. It was also decided to follow the ISO MOX standard specifications (*related to MOX density and isotopics*) and develop a new set of subcritical limits for homogeneous systems. This has resulted in the submittal (*and subsequent approval*) of the *project initiation notification system* form (PINS) in 2007.

SCOPE OF THE CURRENT STANDARD

The standard provides useful subcritical limits for mixed-oxide homogeneous systems as well as for heterogeneous systems pertaining to lattices of mixed-oxide fuel rods.

Subcritical limits were provided for a variety of mixtures, including aqueous solutions, dry [H/(Pu+U) = 0] mixed oxides at theoretical density, and damp [H/(Pu+U) ≤ 0.45] mixed oxides at both theoretical and one-half theoretical density.

Subcritical limits for four different plutonium contents (3, 8, 15, and 30 wt% PUO_2 in PUO_2 + UO_2) were provided. The uranium was assumed to be natural (or depleted). The solutions limits had three different isotopic compositions:

$Pu^{240} > Pu^{241}$,
$Pu^{240} \geq 15$ wt% and $Pu^{241} \leq 6$ wt% and
$Pu^{240} \geq 25$ wt% and $Pu^{241} \leq 15$ wt%

SCOPE OF THE CURRENT REVISION

The Working Group has decided to widen the applicability of the standard by including new subcritical limits for homogeneous systems as follows:

The three plutonium distributions are:

a) 100 wt% Pu^{239},
b) 95 wt% $Pu^{239}Pu^{240}$ and 5 wt% and Pu^{240} and
c) 20 wt% Pu^{240}, a Pu^{241}/ Pu^{240} mass ratio of 11/17, a Pu^{242}/ Pu^{241} mass ratio of 1/11, and the reminder Pu^{239}

Two MOX compositions with MOX densities and corresponding plutonium contents are:

i) Low-density powder - A maximum of 3.50 g/cc with Pu/(U+Pu) = 35 wt%
ii) High-density powder – A maximum of 11.03 g/cc with Pu/(U+Pu) = 12.5 wt%

Two different moderation specifications are covered:

i) 3 wt% H_2O
ii) Optimum moderation

These specifications were selected from the draft ISO MOX standard (currently in the approval stage) after careful deliberations to represent weapons grade plutonium utilization as well as plutonium from spent fuel.

In the development of subcritical limits for the new revision, the Working Group will rely heavily on the calculation results using a wide variety of codes and cross section sets along with the available critical benchmark experiments for validation. Current work includes generating subcritical data for spheres, infinite cylinders and infinite slabs using COG, SCALE and MCNP codes with ENDF/B-V, -VI, –VII as well as JENDL-3.3 and JEFF 3.1 cross section sets.

The Working Group maintains close liaison with the ISO Working Group on the international plutonium-uranium mixed oxide standard and gets regular updates.

REFERENCE:

Song T. Huang, “ANSI/ANS 8.12, Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors, Trans. Am. Nucl. Soc., 91, 625, 2004.

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